

COGNITIVE MODELING OF AIRLINE CREW AUTOMATION ERRORS

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Cockpit automation has changed the roles, responsibilities, and activities of pilots, leading to new types of errors on the flight deck. This research is focused on understanding those errors through the development of a computational cognitive model that describes how pilots interact with automated systems. The cognitive model under development is based on a cognitive task analysis supplemented with eye tracking data collected from commercial pilots flying a low-fidelity simulator.

The Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), National Transportation Safety Board (NTSB), airline pilots, airline management, and researchers all have raised questions about the impact of automation in our airliners. Although some researchers have suggested that automation reduces cockpit workload (Wiener, 1985; Sherman, Helmreich, & Merritt, 1997), others have suggested that automation can increase workload and frustration (Wiener, 1988, 1989).

Although automation was introduced in part to reduce error in the aviation system, errors have continued. Indeed, automation has introduced new errors into the cockpit. This may be a result of automation changing the roles, responsibilities, and activities of the pilots (e.g., from psychomotor flying skills to monitoring and delegating tasks to the automation), which introduces new errors and new types of errors into the system.

One approach to studying error has been to classify or functionally group automation-related errors (e.g., Sarter and Woods, 1995; Wiener, 1989). However, this approach does not allow researchers to pinpoint the causes of errors. Further, this approach does not describe the process of pilot-automation interaction that results in the errors. This makes it impossible to know how to design interventions such as training or the redesign of instruments, displays, or software.

An alternative to the taxonomic approach is cognitive modeling. Detailed cognitive modeling of the processes involved in human-automation systems should give a more complete and systematic picture of automation errors, their detection and possible mitigation. In this research project, we are developing a computational model of the cognitive processes underlying performance in an automated cockpit.

We decided to build our computational model from an *a priori* cognitive task analysis coupled with empirical performance data. To make the task analysis tractable, we needed to focus on a particular aspect of flight. Given the large number of errors that occur during changes in vertical position, we chose to focus on the climb and descent phases. A cognitive task analysis of these phases was then developed using NGOMSL (Natural Language GOMS, see Kieras, 1997). The task analysis focused on the cognitive demands on the pilot responsible for interacting with the automation during these phases of flight. Specifically, the task analysis includes rele-

vant details of the automation interface such as the panels for input and output displays, as well as relevant cognitive processes such as perception, understanding, memory recall, evaluation, and decision-making.

This information was combined with eye tracking data collected from pilots interacting with a low-fidelity simulator. These data informed our design decisions about what information pilots are acquiring from the flight deck while working with automated systems during climb or descent.

Our final goal is a working computational cognitive model, which will be built in a production rule architecture using ACT-R (Anderson & Lebiere, 1998).

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